THE MICROCOSM OF THE DRIFT LINE.

LÆTITIA M. SNOW.

IN the spring of 1902 my attention was called to the extremely interesting life relations of insects along and around the line of drift thrown up by the waters of Lake Michigan, and a series of collections and observations were made between April 14 and May 31. The collections included one hundred and fourteen species, only fifty-one of which it was possible, with the means at hand, to identify. The specimens have, however, been preserved.

PHYSICAL FEATURES.

As with life everywhere, the physical features of the habitat are of great importance to the population. For instance, on Windsor Park beach, including the region north to Seventy-Second Street and south to the Steel Works, the forms were, as a rule, much more abundant than on the two beaches in Jackson Park. On the former beach the gradient is low and the sand smooth ; the water action is rather gentle, the insects stay when the water retreats, and the fine sand keeps them on the surface. At Jackson Park beaches, on the other hand, unless the water has recently been high and beyond the pebble zone, the collecting is poor. In the pebble zone the gradient is greater, the water action greater, and there is the possibility of the insects being washed out again into the lake. That the physical conditions of the beach account for the greater number of forms, and not the fact that collections at the two places were made at different times, may be proved by the fact that on the same day a pebble region of beach north of Windsor Park gave no results, while a smooth region yielded a number of forms.

CAUSES OF DISTRIBUTION.

The waves of the lake wash up great quantities of refuse, among which are numbers of insects. These animals may be either land or water forms; if the former, they have either come directly upon the shore, or have flown lakeward or been blown by an off-shore wind, and then been washed in, dead or dying. On account of the lake current moving southward along this region, specimens collected at Chicago may have come from points farther north (13). To this group of stranded land forms belong the ladybirds (Coccinellidæ), Chrysomelidæ, leaf-eating Scarabæidæ and Carabidæ, possibly the Elateridæ, Lucanidæ, and the Rhyncophora among the Coleoptera, the Lygæidæ and Pentatomidæ among the Hemiptera, the Hymenoptera, Neuroptera, Trichoptera, and Lepidoptera, — all of which are herbivorous. Also to this group belong some predaceous carabids and one roach. To the stranded water forms belong *Benacus griseus*, *Hydrophilus triangularis*, and two other water beetles.

These stranded forms may revive and depart, may serve as food for predaceous forms, or, if dead, fall to the share of the scavenger insects. The flies and ants are undoubtedly scavenger forms, and inhabit this region on account of the food supply. In this class I would also place a small carabid beetle (undetermined) which occurred for a while in great numbers under stones and débris, so as to preclude the idea of its having been stranded during migration. Several small beetles seem to have this scavenger habit; for example, three Staphylinidæ, some Scarabæidæ, and several Carabidæ. In this latter family we find some predaceous forms which seem to inhabit this region normally, to feed on the dying insects or on their destroyers; for example, several black forms (undetermined) and *Galerita janus*. The spiders are also predaceous, and feed on the flies, ants, and other small living insects. I might add that birds come in as a final factor and eat these various forms.

Order of Succession.

These insects do not come all at once, nor "hit or miss," but follow a fairly regular order of succession. It was seldom that the same form was dominant at two visits. Between April 14 and 21 very few insects were found, and no regular record was kept. The temperature was cool and the winds variable during that period. On April 25, after four days of S., S.W., and W. winds, followed by E. and S.E. winds, more forms appeared. Two days of strong (thirty to forty miles per hour) W. wind, followed by a S.E. wind, brought in a few forms on

Date.	Wind previous to Coll.			Wind, Day of Coll.		Temp. F.		Species.		
	Days.	Direction.	Av. Vel.	Direction.	Av. Vel.	Max.	Min.	New.	Old.	Total.
Apr. 25	2	W. to E.	19	S.E.	14	69	42	10	1	11
28	2	W.	$37\frac{1}{2}$	S.E.	15	61	48	3	0	3
May 2	2	E. to N.E.	20	S.W.	18	82	53	37	5	42
12	3	N.E. to E. to N.E.	$21\frac{2}{3}$	N.E.	10	56	43	27	10	37
16	7	N.E. to E.	$16\frac{6}{7}$	E.	10	61	48	6	19	25
23	2	S.W. to S.	$12\frac{1}{2}$	S.E.	10	77	61	13	19	32
27	2	W. to N.W.	15	N.E.	18	50	40	8	7	15
31	2	S.W.	$17\frac{1}{2}$	S.E.	15	75	60	2	14	16

(Data kindly furnished by the U.S. Weather Bureau, Chicago, Ill.)

April 28. All this time the temperature was cool, only once rising over 69° F. On May 2 a N.E. wind (twenty miles), preceded by a W. wind, brought in a good many forms, thirty-seven new species being found, besides several previously collected; the rising temperature (53°–82°) probably influenced the numbers. On May 12 twenty-five new species were found, besides an abundance of old ones. This rich supply was probably due to three days of W. and S.W. wind, followed by four days of N.E. and E. wind (averaging eighteen and three-fourths miles), which continued until May 16 with decreased velocity (thirteen and one-fourth miles), the temperature never exceeding 61° F. On this day only five new

species appeared, but numbers of old ones were found. On May 23, after a warm period with S., S.W., and S.E. winds of low velocity, fourteen new species were collected, a few old ones appearing. A N.E. wind on May 27, preceded by W. and N.W. winds of moderate velocity, brought in countless Colorado potato beetles and ten new species, the temperature dropping twenty degrees in two days. On May 31 a S.W., followed by a S.E., wind brought only two new species, but a good many old ones occurred. These results are placed on the preceding page in tabular form.

DOMINANT FORMS.

The first form to predominate notably was *Chrysomela elegans* (May 2), while *Hippodamia parenthesis* came in a good second. The little *Coccinella sanguinea* occurred throughout the season in about the same numbers, but absence of other forms made it at times the dominant species. Black carabids occur also throughout, but never as dominant forms. The next visit, May 12, showed *Diabrotica vittata* as the characteristic species, while of Chrysomela only a few specimens were found. The small brown and black scavenger carabid was present in great numbers, and should probably be classed as the dominant form. *Coccinella sanguinea* was numerous, as were also black carabids. The following collection showed the Diabrotica, although not the characteristic species, still occurring in fair numbers; the scavenger carabid seemed to be the most numerous form, with quantities of *Coccinella sanguinea*. Of the larger forms Bombus sp.? and *Hydrophilus triangularis* were the most important. This time (May 16) marked the first occurrence of *Galerita janus*, and the flies were first noted. The various forms of Hemiptera occurred throughout the collecting trips, but were never dominant forms. On May 23 the Colorado potato beetle (*Leptinotarsa decemlineata*) was the dominant form at Jackson Park. This appears to have been the vanguard of the great "migration" which took place on, or just before, May 27; for on that date the beach at Cheltenham was nearly covered with the beetles,

dead, dying, or active. In the latter case they had in many instances crawled up on stones and driftwood, until the surfaces of such articles were, in places, covered with them, sometimes two layers deep. On May 31, however, very few live ones remained, and the total number of individuals was greatly diminished. The form that approached the potato beetle in number on May 27 was the May beetle, or June bug (Lachnosterna sp.?).

Besides those above mentioned, other forms occurred in greater or less abundance at different times, some running through the whole period, some starting late and continuing to the end, some starting early and disappearing.

Migrations.

Would the fact that certain forms culminated at certain times indicate that they simply reached the adult stage at that time, laid their eggs and disappeared, or that they were performing mass movements, broadly called "migrations"? The great swarm of potato beetles on May 27 closely resembled mass movements recorded by many authors, in that the number was large and that the animals were found on the 27th and by the 31st had almost entirely disappeared, no new ones appearing. If it were merely a general emergence, it is not likely they would have been found only along the lake front. This great washing up of one species recalls the predominance of crickets (*Nemobius fasciatus*) described by Needham (1).

Much has been written on this subject, both descriptive and theoretical, but the problems as to the "why" and "whither" of insect flights have never been solved. The search for food has been suggested as the cause, and the suggestion has been accepted by many as at least a secondary factor. In some cases over-production, followed by a scarcity of food, would seem a sufficient reason for the movement; as, for instance, the migrations of locusts, both in this and other countries (2, 3). Certain examples of the flights of dragon flies point to the same cause (3, p. 509; 4; 10). Kobelt (3) quotes Gätke as saying: "Es ist schon darauf hingewiesen worden,

dass auch die Bewegung der Nachtschmetterlinge meteorologischen Beeinflussungen unterworfen sind. Diese Ansicht stützt sich auf wiederholte Beobachtungen, nach welchen dieselben unter gleichen Bedingungen wie die Vögel, und fast immer zusammen mit diesen in ostwestlicher Richtung hier vorbeiziehen"; which may be the key to the whole question. As far as I am aware, no barometric observations have been made directly on the subject of insect migration (15).

That a feeling of hunger is not alone a sufficient cause for some of the direct flights recorded, is shown by the fact that butterflies often continue in their path, over the very flowers they use for food, only a chance one stopping on the way (3, p. 509). Also, if they simply spread out to find food, the progression would be diffuse, directions inclined to be random, and the advance a gradual one, as is the case with the spring "dispersal through isolated individuals" of Danais (5), which go north as the spring advances, various generations taking part in the advance.

In many instances the direction of flight has not been noted, but in Europe the general tendency seems to be from east to west. In our country, however, no such law appears to hold. More attention has been paid to the consideration of whether the animals, chiefly butterflies, flew against or with the wind, some holding that the latter feat was impossible. That it is at least possible, has been shown by some direct observations (6, 7).

It has been suggested that, as in some cases the swarm was composed of individuals of one sex (males), the flight originated in a search for mates; but as the absence of females can be explained in some instances by their wingless condition (8, 1900, p. 13), while in most observations the sexes were nearly equal in number, this cause may apparently be ruled out.

If they are then not necessarily merely drifted by the wind, or impelled by immediate hunger or by the sexual instinct, why do they follow such direct routes, fly with such apparent aim, and often repeat the flight at intervals? Walker attributes it to "a propensity to migrate" (8, 1901, p. 353), thus throwing it back upon hereditary tendencies, while Keferstein (4) adds to over-production and some aid from wind,

an unknown impulse to take a common migration. Riley (5) makes the statement that "all insects acquire the migratory instinct when crowded together through excessive multiplication." The probable response to meteorological influences has been noted.

Hancock (9) distinguishes between dispersal and migration in the statement, "Individuals of a species which effect a more or less regular periodical change in their habitat are truly migratory. Migrations may be primary, consisting of local flights, such as movements by insects hatched in temporary regions, to which they confine themselves to passing to and fro, from point to point; or secondary, as the repeated periodical changes of residence covering foreign fields, which naturally establishes a nomadic habit." In addition to these distinctions it is suggested that the term "migrations" be confined to periodical changes of habitat resulting from the normal sequence of temperature and season, while such abnormal occurrences as the devastating swarms of Rocky Mountain locusts or irregular and unusual swarms, as in certain instances of butterfly, moth, and dragon-fly flights, be given, temporarily at least, the term "immigration." Mr. Hancock's "primary migrations or local flights" would be simply dispersal flights of individuals or groups of individuals within their area of distribution.

Was the flight of Colorado potato beetles on May 27 a dispersal (or local) flight, diverted out of its course and driven lakeward by west winds, or was it a periodic migration? The predominance of other insects at various times was probably due to the spreading of groups of individuals by local flights: may not these local flights give some evidence of the dispersal paths of various species?

Conclusion.

By whatever means the animals reached the region, — by migration or dispersal movement, — the life relations of the beach are not altered. We have here a little community of food providers and food obtainers, whose population varies with the season, the wind (probably), the beach conditions,

and the relative abundance of the various forms. For example, we found (1) the occurrence was in succession; (2) the population increased apparently at times when an offshore wind was followed by a lake breeze; (3) it also increased with the temperature; (4) the greatest numbers occurred on beaches of low gradient and smooth, fine sand; (5) the abundance of scavenger forms depended upon the abundance of dead herbivorous and predaceous forms and other refuse; (6) the abundance of predaceous forms depended upon the presence of the active scavenger and herbivorous and smaller predaceous forms.

I gratefully acknowledge the kindness of Dr. Charles B. Davenport and Mr. Charles C. Adams, and present my thanks for their assistance in identification and for valuable advice and suggestions.

Hull Zoölogical Laboratory,
July 18, 1902.

List.

Of the one hundred and fourteen species collected fifty-one were identified, the whole collection being placed in the following orders and (where possible) families: —

Coleoptera, 75: Carabidæ, 33; Scarabæidæ, 10; Chrysomelidæ, 9; Coccinellidæ, 7; Staphylinidæ, 3; Hydrophilidæ, 3; Cerambycidæ, 2; Elateridæ, 2; Silphidæ, 1; Histeridæ, 1; Halipidæ, 1; Lucanidæ, 1; Curculionidæ, 1; Calandridæ, 1.

Hemiptera, 11: Pentatomidæ, 5; Lygæidæ, 2; Reduviidæ, 1; unknown, 1.

Diptera, 10: Muscidæ, 5; Syrphidæ, 2; Phoridæ, 1; Tachinidæ, 1 (?); unknown, 1.

Hymenoptera, 9: Apidæ, 4; Formicidæ, 1; Vespidæ, 1; Andrenidæ, 2; Tenthredinidæ, 1.

Lepidoptera, 3: Arctiidæ, 2; Noctuidæ, 1.

Trichoptera, 2: Phryganeidæ, 2.

Neuroptera, 2: Chrysopidæ, 2.

Orthoptera, 1: Blattidæ, 1.

Arachnida, 1: (Lycosidæ?)

IDENTIFIED SPECIES.

Name.	First collected.	Dominant.	Last collected.
COLEOPTERA			
Aphodius fimetarius	April 14–21	—	May
Hippodamia 13-punctata	25	—	12
Hippodamia parenthesis	25	—	2
Hippodamia convergens	25	—	2
Coccinella sanguinea	25	—	31
Cyllene pictus	May 2	—	—
Necrophorus marginatus	2	—	—
Coccinella 9-notata	2	—	31
Chrysomela elegans	2	2	31
Anatis 15-punctata	2	—	31
Agonoderus pallipes	2	—	23
Casnonia pennsylvanica	2	—	16
Drasterias elegans	2	—	12
Disonycha triangularis	2	—	—
Megilla maculata	12	—	27
Diabrottica vittata	12	12	16
Diabrottica 12-punctata	12	—	—
Leptinotarsa 10-lineata	12	27	31
Calosoma scrutator	12	—	31
Calosoma wilcoxii	12	—	31
Elaphrus ruscarius	12	—	—
Platynus sp.?	12	—	16
Galerita janus	16	—	23
Hydrophilus triangularis	16	—	31
Lucanus dama	23	—	27
Calosoma calidum	23	—	31
Euphoria inda	23	—	—
Phymatodes sp.?	23	—	—
Geopinus incrassatus	23	—	—
Lachnosterna sp.?	27	—	—
Cotalpa lanigera	27	—	—
Sphenophorus sp.?	27	—	—
Ligyrus gibbosus	31	—	—
Coptocycla aurichalcea	31	—	—
HYMENOPTERA			
Lasius brunneus	April 15–21 +	—	—
Polistes variatus	May 2	—	16
Prosopis sp.?	2	—	—
Augochlora sp.?	2	—	—
Bombus sp.?	12	—	27
Anthophora sp.?	27	—	—
Nomada sp.?	27	—	—

IDENTIFIED SPECIES (*Continued*).

NAME.	FIRST COLLECTED.	DOMINANT.	LAST COLLECTED.
DIPTERA			
Syrphus torvos (?)	April 25	—	May 16
Lucilia cæsar	28	—	31
Scarcophagus georgiana.	May 23 on?	—	—
HEMIPTERA			
Oncopeltus fasciatus	May 2	—	—
Benacus griseus	16	—	—
LEPIDOPTERA			
Estigmene acræ (?)	May 27	—	—
Eyprepia (?)	27	—	—
ARACHNIDA			
Present throughout			

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